RESULTS OF A STUDY TO DEVELOP AN ALTERNATIVE TYPE OF CANE FOR SAFE MOBILITY OF OLDER BLIND INDIVIDUALS THAT IS ALSO USABLE FOR YOUTHS

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Introduction

This paper describes a research study to develop an effective design for an adapted cane for visually impaired elderly based

on a similar device used by multiply impaired children. The goal of this study was accomplished by:

- evaluating alternative mobility devices (AMD) [1]. currently being used;
- surveying Orientation and Mobility (O&M) specialists in the United States and Canada concerning their experiences with AMDs (ie, critical evaluations, undesirable features, and ideal features);
- using survey results to design and develop an effective, durable prototype; and
- conducting mechanical and functional evaluations of the prototypes.

O&M specialists field tested this new prototype to evaluate wear, handle placement, weight, maneuverability and structural durability.

Background

O&M specialists first used AMDs as precursors to the long cane. These precanes were used for two main purposes: as a protective device for the children that was easy to learn (Bosboch, 1988; Foy, C.J., Kirchner, D. & Waple, L., 1991; Kronick, 1987; Clarke, Sainato, & Ward, 1994) and to begin skill development that would transfer later to use with the long cane (Kronick, 1987; Foy, C.J., Kirchner, D. & Waple, L., 1991). Later, AMDs were used as permanent mobility devices for individuals

[1] In this paper, AMD refers to any device other than the traditional long cane that promotes safe mobility

unable to use a long cane. Some devices are shown in Figures 1-13. They require minimal skills to use, provide full coverage across the width of the body; and are in constant contact with the ground, providing optimum tactile and audio feedback. Most designs have a bumper bar across the bottom to clear a wide path and to absorb impact (Figures 2-10). The user pushes the AMD in the direction of travel and does not need the strength and coordination required by the long cane. In some cases, individuals with poor gait have experienced significant improvement in gait when using an AMD. (Kronick, 1987) In addition, O&M specialists have reported increased travel abilities among preschoolers (Foy, C.J., Kirchner, D. & Waple, L., 1991; Kronick,1987; Clarke, Sainato, & Ward, 1994). Fisk (1986) indicated that AMD travel techniques are needed to develop the full abilities of multiply impaired individuals and that AMDs have great potential for older adults.

Children have used wheeled push toys like the **child's shopping cart**. (Foy, C.J, Von Scheden, M. & Waiculonis, J. (1992) and **Hula Hoops** (Figure 1) as AMDs. These devices are appropriately sized for children and are easy and fun to use. The shopping cart provides support, is easy to grip, and rolls smoothly over most surfaces. The Hula Hoop has several advantages: it is flexible to absorb shocks when the child bumps into obstacles, the Hoop is smooth and slides easily over most surfaces, and it is inexpensive and readily available. Most

importantly, using the Hoop does not require the child to learn a specific grip or technique. The user merely pushes the Hoop in the direction of travel and is able to travel independently after short instruction (Bosbach, 1988). The drawbacks are that the Hoop can be awkward to handle because of its large diameter and it only has one contact point in the center of the travel path and therefore cannot detect side drop-offs or side obstacles low to the ground (Bosbach, 1988).

The **T-bumper** (Figure 2) is constructed from a push broom. Castor wheels are attached at either end of the broom base. A crossbar at the top creates a "T" handle. Although the device is wide and allows for safe travel, it is heavy and awkward to maneuver through doorways. The sharp edges on the bumper broom base are a safety hazard for other pedestrians (Bosbach, 1988). This design has been used to construct similar devices from PVC such as **the I-Shaped Bumper Cane with Skids** (Figure 3). The **Freestanding** Cane (Figure 4) was developed for multiply impaired children and young adults by the O&M specialists at the Missouri School for the Blind. The **Hoop Cane** (Figure 5) and the **PVC Cane** (Figure 6) used by the Texas School for the Blind are trapezoids constructed from Hula Hoops and PVC respectively. The bottom bar slides along the ground and functions as a bumper bar. The width of the bar is determined by the width of the user's shoulders or of the user's gait, whichever is greater. The top bar is wide enough

to be gripped by both hands. These designs provide better coverage, are smaller, and are less awkward than the Hula Hoop. However, the bumper bar tends to snag on uneven terrain as it slides across the ground and does not improve the user's ability to detect side drop-offs.

In 1991, Foy, et al., reported the development of the **Connecticut Precane** (Figure 7). The Precane is inexpensive, and O&M specialists are able to construct it with PVC pipe at home or at work if an oven is available to heat and bend the PVC. Like the other devices, use of the Precane requires minimal skills. The user needs only to push it in the direction of travel. The Precane is constructed wide enough to provide full protection without becoming a hazard to the user or others. The PVC pipe is flexible and absorbs shocks. The design is similar to the Hoop Cane and the PVC Cane with one critical modification: the Precane has two curved runners attached to the bottom of the cane. This adaptation allows the device to glide smoothly over most surfaces and enables the user to detect side drop-offs. O&M specialists at the Connecticut State Board of Education and Services for the Blind and the Arizona School for the Deaf and Blind reported successful use of the Connecticut Precane by visually impaired older adults and multiply-impaired children and adults during the years of 1991 and 1992 (Foy, C & Siffermann, E, 1992). Clients experienced dramatic increases in confidence and independent travel when

using AMDs compared to previously (Kronick, 1987). Clients with multiple impairments have improved their gait through use of the Connecticut Precane (Foy, 1992; Siffermann, 1992).

The most significant problem reported by specialists using the PVC canes is the wear of the runners outdoors. Constant contact on sidewalks and other abrasive surfaces wears through the wall of the PVC pipe in a few hours. Because most canes are constructed of hollow pipe instead of solid rods, the wear produces sharp edges that are a safety hazard and make the canes difficult to push.

AMDs have other disadvantages. Several designs do not allow the user to detect side drop-offs. Most are bulky and difficult to transport and store. The Connecticut Precane has runners that can detect side drop-offs, but the runners protrude ahead of the bumper bar, making maneuvering around obstacles difficult. Some designs have a bumper bar that slides along the ground that clears a wide path but snags on uneven terrain.

Only four of the seventeen AMDs evaluated by O&M specialist in this project were commercially produced. They were the Hula Hoop, the toy shopping cart, the Push Pal and the Walk Alone; the later two actually marketed as AMDs. O&M specialists must spend valuable teaching time designing and building AMDs for their clients.

There is scant information in the literature regarding adult use of an AMD as a precurser to the long cane or as a long-term mobility device. Most of the work done with AMDs has occurred at residential schools for the blind or with children in preschool or elementary school, most often using the AMD as a precane. By the year 2020, it is predicted that 4.6 million older adults will experience severe visual impairments (Crews, 1991). The US National Center for Health Statistics (1977) estimates that 59% of non-institutionalized individuals with severe visual impairment are multiply-impaired. People who lose their vision are uncomfortable performing activities of daily living and participating in social activities and feel they must rely on others for help. Multiple impairments compound the problems for this population. Isolation, loneliness, and depression may occur (Kemp, et al, 1990; Roybal, 1985; Crews, 1985). Statistics show that people who are visually impaired are five times more likely to be institutionalized than any other group and that the older blind population is institutionalized more often than the older sighted population (Rinaldo, 1985). Some people are institutionalized, not for medical reasons, but because they have not been taught independent living skills. Without these skills, it is unsafe for them to live alone and family members may be unable to provide the necessary support (Rinaldo, 1985; Roybal, 1985; Crews, 1985; Horowitz, 1994). To continue to perform activities of daily living and

participate in community activities, people who are visually impaired must be able to move about their environments safely and efficiently. Elderly people are excellent candidates for rehabilitation and are eager to learn the O&M skills that allow them to function independently (Roybal, 1985; Crews, 1985, 1992; Williams, 1984; Casabianca, 1985; US House of Representatives, 1992). A significant part of O&M instruction is learning to use the long cane, but some adult populations are unable to use this device effectively. They may be afraid of the stigma of a long cane, they may not have the wrist strength to manipulate the long cane, or they may be congenitally impaired and unable to use the long cane. Without an appropriate alternative, the amount of independence these people can achieve is limited. Hill & Hill (1991) stated that using a precane could increase the mobility of the older adult population, as did Foy, C.J., Von Scheden, M. & Waiculonis, J. (1992).

The VA AMD, designed specifically for special adult populations, will enhance travel abilities and promote walking and physical fitness which can prevent the loss of function that occurs with age can be prevented by exercising which promotes good physical and mental health (Brown & Rose, 1965; Shepard, 1990). Walking is the most popular exercise among people over age 65 and is one of the safest forms of exercise for this age group (Vital and Health Statistics, 1989;

Hanson, 1986; Carver, 1986).

Methods

Evaluation of Current AMD Designs - Phone Interviews

Twenty-six (26) O&M specialists who previously provided AMDs to their clients were interviewed to determine the benefits and drawbacks of existing AMDs. Collectively, these O&M specialists had instructed 276 clients to use an AMD and had experience with seventeen (17) different AMDs (Graph 1). The Hula Hoop, Toy Shopping Cart, WalkAlone (Figure 14) and PushPal (Figure 15) are commercial products. All other AMDs were designed by O&M specialists in their home or work settings. Each interviewee was asked to select the two most preferred AMDs and the least preferred AMD. The frequencies of preferred responses were: Connecticut Precane (19.6%), the PVC Cane (13.0%), the Offset Pre-Cane (10.9%) and the Rectangular-shaped Cane (10.9%). The most common reasons that elderly clients and previous users used an AMD were lack of precision with the touch technique, followed by lack of cognitive abilities. The opposite was true of the multiply impaired clients whose most common reasons for using an AMD were lack of cognitive abilities, followed by lack of precision with the touch technique. Many of the clients fell into several of the categories (Graph 2).

The determination of the VA AMD length was based personal

features such as gait, balance, walking speed and reaction time more than on environmental features like indoor/outdoor changes and unfamiliar environments (Graph 4). The width of the bumper bar was appropriate for most of the clients. O&M specialists reported that the distance between the wheels and runners should be greater than the width of the clients' gait. However, about eleven percent (11%) of the elderly clients, forty percent (40%) of the multiply impaired clients, and thirty-five percent (35%) of the previous users had a gait width greater than the distance between the wheels or runners. O&M specialist preferred wheels over runners for sixty-seven percent (67%) of the elderly clients, sixty percent (60%) of the multiply impaired clients and seventy-two percent (72%) of the previous users. O&M specialists preferred the handles for the majority of participants in all groups.

Because the number of O&M specialists interviewed was small (26) and the variety of AMDs in use by these specialists was large (17), the number of times each AMD was classified as a preferred or non-preferred was quite small and occasionally an AMD was only rated once. Because of this, the AMDs were classified according to: 1) shape, which relates to maneuverability, 2) type of ground contact, which relates to durability and performance on various surfaces, and 3) number of ground contact points, whcih relates to drop-off detection. Graph 3 shows the distribution of the preferred and non-

preferred AMDs.

The phone interviews can be summarized as follows:

- Most AMDs were rectangular. Although less bulky and more lightweight, the open frame of I-shaped AMDs results in a tendency to snag on obstacles such as chair legs and doorways.
- Wheels, rollers, runners and skids were all used frequently.
- Two points of contact were preferred to provide side drop-off detection.
- Waist height was the preferred hand placement.
- Construction costs ranged from $2 to $50 and time ranged from 20 minutes to five hours. Maintenance costs over one year ranged from $0 to $3 and time ranged from zero to three hours. The time before an AMD needed repairs ranged from two to twelve months and the life of the AMDs ranged from 15 days to six years.
- Wheels are more durable than runners, rollers or skids when used outdoors, but they are more expensive, difficult to align and hard to incorporate into the design.
- The most common construction method was to join sections of PVC with glue. Although this is the simplest and easiest method, the glue is permanent, making it difficult to repair or replace small sections of the AMD;

usually a new AMD had to be built.

VA AMD Design

The VA AMD (Figure 16) was developed based upon the results of the telephone interviews and recommendations from consultants. An O&M specialist and a mechanical engineer, working together, designed the VA AMD to be safe, efficient and commercially manufacturable. Two adjustable sizes were built, one for preschool to elementary sized children, narrow and height adjustable from 29 inches to 41 inches; the other for taller children and adults, wider and adjustable in height from 41 inches to 53 inches. Aluminum tubing was used to construct the VA AMD because it is light, soft and bendable. The shape was a cross between the open-frame, I-shaped AMDs, which are lighter and less bulky and the closed-frame, rectangular AMDs, which are sturdier and less likely to snag on obstacles.

The VA AMD had six major parts: a bumper, an upper crossbar, a right and left handle shaft and a right and left wheel shaft. The bumper bar, joining the right and left wheel shafts, was curved at the sides so that it would slide easily around obstacles without snagging. It was positioned in front of the wheels/runners to protect them from impact. The crossbar, joining the right and left handle shafts, provided structural rigidity. The handle shafts consisted of a straight section of aluminum bent at a 45 degree angle at one end to

form a handle (during initial development and O&M specialist tested two PVC pre-prototypes with similar handles, and reported that the handles encouraged upright posture). The handle shafts were turned such that the handles angled outward at approximately 45 degrees. A rubber grip was placed on each handle to provide a firm grasp. For size adjustability and portability while not in use, each handle shaft telescoped into the corresponding wheel shaft. A snap-button latch at the end of each handle shaft was used to lock the handle shaft into position in the wheel shaft. The wheel shafts consisted of a straight section of aluminum bent at a 60 degree angle at one end to accommodate a wheel or runner. Seven equally spaced holes on the interior side of each wheel shaft were used for locking the latch on each handle shaft. A plastic sleeve was inserted into the short section of each wheel shaft. Interchangeable caster wheels and curved runners snapped into the plastic sleeve. Caster wheels were used because they swiveled and made it possible to move the VA AMD in all directions. The nylon runners were constructed from solid, 0.5 inch diameter, 8.5 inches long, nylon rod. One end of the rod was shaped to match the contours of the plastic sleeve, then the rod was heated and curved. The runners were provided because many O&M specialists felt that wheels would be too fast for some clients or would too easily change the line of direction. They provided additional tactual feedback and drag resistance which would slow the forward momentum of the

user.

Field Testing the VA AMD

Study Population: 100 individuals who currently were unable to use a long cane were to participate in this phase of the project. They were categorized into three groups: thirty individuals 60 years olds or older; thirty individuals of any age who could use the adult-sized AMD, were multiply impaired and had never used AMDs in the past; and forty individuals of any age who had used AMDs in the past. The project required the O&M specialist to provide a minimum of one hour each week for five weeks, instructing and/or observing each client who used the AMD prototype. At the conclusion of the fifth week, the O&M specialist completed a questionnaire for each client.

The following table shows the number of individuals in each group, the average age and the age range.

Group	Type	n	average age	age range
One	Elderly	18	72.4	60-87
Two	Multiply Impaired	28	31	12-55
Three	Previous Users	37	14	2-47

Survey Results: In all, 83 questionnaires were returned. Fifty-five percent of the elderly participants, 75 percent of the

multiply impaired participants and 81 percent of previous users will continue to use the VA AMD according to the O&M specialist. O&M specialists rated the VA AMD as above average for an AMD and rated their client as safe or somewhat safe when using it for sixty-seven percent of the elderly participants, 72 percent (72%) of the multiply impaired participants, and 93 percent of previous users (Graphs 5 &6). Most clients' gait, travel safety and travel confidence improved with the use of the VA. Approximately 90% of all clients believed the VA AMD to be socially acceptable.

The O&M specialists reported that the VA AMD was able to adequately detect obstacles in the path, down curbs, up curbs, down stairs, up stairs, doorways and hallways. Although few clients encountered side drop-offs, the majority of those who did rated the VA AMD's ability to detect them as good (Graph 7). Graph 8 shows a comparison of the VA AMDs ability to detect a variety of obstacles. O&M specialists reported that the size of the VA AMD makes it difficult to transport up and down stairs. Several broke while in use, due to the weak points at the bend of the crossbar at the top screw and at the bend of the bumper bar at the bottom screw.

Conclusions

Most AMDs have been used to teach skills to preschoolers and have been called "precanes" because the skills were thought to

transfer to use with the long cane, current practice seems to be that children and adults alike who may not be able to use a long cane could use this type of device as a long term device for safety.

Many children and adults cannot use a long cane for any number of reasons. O&M specialists are looking for alternatives to the long cane to provide increased level of independence over their previous functional abilities for those individuals. The high level of interest in this project and at international professional conferences in the field indicates that there is a definate place for AMDs in the field of O&M.

Future Research

Research must continue to develop better devices and instructional practices and strategies for using AMDs.

Conclusions

1. The width of the client's gait should be the same or less than the distance between the wheels or runners so that the client will be alerted to side drop-offs by the wheels or runners falling over the edge.

2. There is a need for an alternative method of joining the wheels/runners to the AMD that makes it easier to insert the wheel or runner and remove the wheel or runner when needed.

3. Rubber wheels should be used instead of plastic wheels to decrease the noise made by the device.

4. The VA AMD is difficult to handle while opening and going through doorways and ascending and descending stairs. Specific AMD travel techniques need to be developed.

5. The joint at the bend of the crossbar and the bumper bar needs to be redesigned to eliminate breakage due to stress that occurred when the VA AMD was in use. (This has been accomplished by using a thicker grade of aluminum in the construction and changing the attachment joint at the bars.)

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